SCIENCE:

A WEEKLY RECORD OF SCIENTIFIC PROGRESS.

JOHN MICHELS, Editor.

PUBLISHED AT

TRIBUNE BUILDING, NEW YORK.

P. O. BOX 3838.

SATURDAY, JUNE 18, 1881.

AT the last meeting of the "*American Chemical Society*," Professor A. R. Leeds called attention to the reported adulteration of certain articles of food, and made special reference to the adulteration of sugar and syrups, with glucose.

The result of Dr. Leeds' examination of sugar shows, that it was of excellent quality and almost free from any adulteration, and that he was enabled, after investigations, to "contradict with equal decisiveness, the notion that table syrups are largely, almost universally, adulterated with glucose syrups."

As Dr. Leeds stated that one of the objects of his paper was to correct, what he calls, sensational reports of adulteration, and to place on record his own scientific work as evidence that adulterations to a large extent do not exist, it may be prudent to test the integrity of his work, by comparing it with results achieved by another chemist, having a high reputation as an analyst, who appears to have made investigations covering the same ground, as that instituted by Professor Leeds. We allude to Professor Harvey W. Wiley, whose paper on "Glucose and grape-sugar" appears at an opportune moment. According to Professor Wiley, the manufacture of glucose is conducted on a scale which will result in eleven million bushels of corn being used for that purpose during the present year, and as a bushel of corn will produce about 30 pounds of glucose, it would appear that over three hundred million pounds of glucose will be placed on the market during the year 1881, with every indication that the quantity will be doubled in 1882.

What becomes of all this glucose? Professor Wiley states that some of it is used for brewing beer, taking the place of malt; it is also given as a food for bees; "all soft candies, waxes and taffies, and a large proportion of stick-candies and caramels are made of glucose"; but "A VERY LARGE PROPORTION OF ALL THE GLUCOSE MADE IS USED FOR THE MANUFACTURE OF TABLE SYRUPS." * * * "When these syrups are sent into the shops, they are sold to consumers under such altisonant names as Maple Drip, Bon Ton, Upper Ten, Magnolia, Extra Choice, Golden Drip, White Loaf Drip," etc., etc. * * * "Dealers tell me that these syrups, by their cheapness and excellence, have driven all others out of the market. So much is this the case that it is no longer proper to call glucose the 'coming syrup.' It is the syrup which has already come."

"Grape sugar is used chiefly for the adulteration of other sugars. When it is reduced to fine powder; it can be mixed with cane sugar in any proportion, without altering its appearance. Since the grape-sugar costs less than half the price of cane sugar, this adulteration proves immensely profitable."

We do not propose to decide upon the issue thus raised by Professors Leeds and Wiley, but as both admit to have spoken after a full investigation, it is difficult to discover how results so different were arrived at. We believe that Professor Leeds reported correctly on the samples as he found them, but if Professor Wiley is correct, the former must have been very fortunate, or, perhaps, unfortunate, in the selection of his samples.

We are in receipt of a communication, stating that glucose sugar has now an immense sale, and that in the West, nine-tenths of the syrups on the market have but 5 to 15 per cent. of cane sugar.

Possibly in first-class stores in New York City, the sugars and syrups offered for sale are genuine, but it appears folly to shut our eyes to the immense use of glucose and grape-sugar for mixing purposes.

If Professor Leeds wishes his future communications on adulteration to be read with "vivid interest," or his reports to reach what he terms, "a commanding position in the literature of adulterations," he will offer some evidence that Professor Wiley is in error, while a few facts, showing the destination of the 500 tons of glucose and grape-sugar manufactured every day, will be timely and welcome.

We find that the first cost of glucose and grape-sugar is about one cent a pound, and that it is sold direct for three to four cents a pound. The manufacture therefore of glucose is a profitable industry, and one likely to be conducted with spirit and enterprise.

Is glucose wholesome? It may be early to answer this question, as some physicians are opposed to its use, but, as an article of food, it is now generally acknowledged to be a wholesome product, and if carefully and properly made, free from any deleterious substances. We therefore fail to find any reason why this thriving industry should not be conducted openly, and the product sold on its merits, thus escaping the odium which is cast on all counterfeit substances.

THE latest number of the journal of the *Royal Microscopical Journal* is largely occupied with papers discussing the question of angular aperture; that by Mr. Frank Crisp disposes of 60 pages, and another by Professor E. Abbe occupies 30 pages.

The editor of the *American Journal of Microscopy* proposes to offer the whole of Mr. Crisp's paper in a forthcoming number; those, therefore, who are interested in the subject can read it there in its integrity; in the meantime, the résumé to be found in another part of this issue, may be found useful. We may remind our readers that this discussion has continued for the last ten years, with the prospect of a settlement of the question as remote as ever.

Probably the Counsel for Cadet Whittaker, at the recent court-martial, was not aware of the magnitude of the question when he asked Professor Piper, of Chicago, "What is Angular Aperture?" Perhaps Mr. Park Benjamin, who is said to have prompted the question, will himself answer the question.

A WRITER in "*The Journal of Science*" defends the old system of "Weights and Measures" as against the metric system. He admits that in refined scientific investigations the metric system has advantages, but he is opposed to it for purposes of daily life and retail trade. He maintains that the nomenclature and the notation of the metric system requires reorganizing, with plain, simple and short names for its various grades, to be expressed in such a manner as to banish the decimal point beyond all ordinary transactions.

It appears to us that the metric system requires little apology for its defects, when, as the writer admits, the old system is complicated, and has a total want of unity in its weights and measures. In England, a peck of potatoes, apples, etc., is 20 lbs. in Lancashire, 21 lbs. in Sheffield, 14 lbs. in Huddersfield, and 16 lbs. in Halifax. A stone of anything is in some districts 14, and in others 16 lbs. A gill in the north of England is half, but in the south only a quarter, of a pint. Almost every county has its peculiar acre, and these examples might be multiplied.

A WRITER in "*The Astronomical Register*" draws attention to an error in the "*Memoir*" of Sir William Herschell, and repeated by Professor Holden, in "*Sir William Herschell, his Life and Works*," in styling Sir William a baronet.

We find Mr. James L. McCance is correct in making the inference that Sir William Herschell was created a knight, only. His son, Sir John Frederick William, was created a baronet in 1838.

We notice that Burke's Peerage affords little information on the subject, giving no date when the great astronomer was created a knight. Professor Holden mentions the year 1816 as the date of that event.

THE UNITY OF NATURE.

BY THE DUKE OF ARGYLL.

VIII.

THE ORIGIN OF RELIGION CONSIDERED IN THE LIGHT OF THE UNITY OF NATURE.

If any one were to ask what is the origin of hunger or what is the origin of thirst, the idleness of the question would be felt at once. And yet hunger and thirst have had an origin. But that origin cannot be separated from the origin of Organic Life, and the absurdity of the question lies in this—that in asking it, the possibility of making such a separation is assumed. It involves either the supposition, that there have been living creatures which had no need of food and drink, or else the supposition, that there have been living creatures which, having that need, were nevertheless destitute of any corresponding appetite. Both of these suppositions, although not in the abstract inconceivable, are so contrary to all that we know of the laws of Nature, that practically they are rejected as impossible. There always is, and there always must be, a close correspondence between the intimations of sensibility and the necessities of Life. Hunger is the witness in sensation to the law which demands for all living things a renewal of force from the assimilation of external matter. To theorize about its origin is to theorize about the origin of that law, and consequently about the origin of embodied Life. The Darwinian formula is not applicable here. Appetite cannot have arisen out of the accidents of variation. It must have been coeval with organization, of which it is a necessary part. The same principle applies to all elementary appetites and affections, whether they be the lower appetites of the body or the higher appetites of the mind. They exist because of the existence of certain facts and of certain laws to which they stand in a relation which is natural and necessary, because it is a relation which is reasonable and fitting. Really to understand how these appetites and affections arose, it would be necessary to understand how all the corresponding facts and laws came to be. But in many cases—indeed in most cases—any such understanding is impossible, because the facts and the laws to which every appetite corresponds are in their very nature ultimate. They are laws behind which, or beyond which, we cannot get. The only true explanation of the appetite lies in the simple recognition of the adjusted relations of which it forms a part; that is to say—in a recognition of the whole system of Nature as a reasonable system, and of this particular part of it as in harmony with the rest. Any attempted explanation of it which does not start with that recognition of the reasonableness of Nature must be futile. Any explanation which not only fails in this recognition, but assumes that the origin of anything can be interpreted without it, must be not only futile but erroneous.

Men have been very busy of late in speculating on the origin of Religion. In asking this question they generally make, often as it seems unconsciously, one or other of two assumptions. One is the assumption that there is no God, and that it must have taken a long time to invent Him. The other is that there is a God, but that men were born, or created, or developed, without any sense or feeling of His existence, and that the acquisition of such a sense must of necessity have been the work of time.

I do not now say that either of these assumptions is in itself inconceivable, any more than the supposition that at some former time there were creatures needing food and drink and yet having no appetites to inform them of the fact. But what I desire to point out is, first, that one or other of these assumptions is necessarily involved in most speculations on the subject, and secondly, that, to say the least, it is possible that neither of these assumptions may be true. Yet the method of inquiry to be pursued re-

specting the origin of Religion must be entirely different, according as we start from one or other of these assumptions, or as we reject them both. If we assume that there is no God, then the question how Mankind have come so widely to invent one or more of such imaginary Beings, is indeed a question well worthy of our utmost curiosity and research. But, on the other hand, if we start with the assumption that there is a God, or indeed if we assume no more than that there are Intelligences in the Universe superior to Man, and possessing some power greater than his own over the natural system in which he lives, then the method of inquiry into the origin of Religion is immensely simplified. Obviously the question how Man first came to recognize the existence of his Creator, if we suppose such a Being to exist, becomes in virtue of that supposition relegated to the same class as the question how he first came to recognize any other of the facts or truths which it concerns him most to know. Indeed from its very nature this truth is evidently one which might be more easily and more directly made known to him than many others. The existence of a Being from whom our own being has been derived involves, at least, the possibility of some communication direct or indirect. Yet the impossibility or the improbability of any such communication is another of the assumptions continually involved in current theories about the origin of Religion. But no such assumption can be reasonably made. The perceptions of the Human Mind are accessible to the intimations of external truth through many avenues of approach. In its very structure it is made to be responsive to some of these intimations by immediate apprehension. Man has that within him by which the Invisible can be seen, and the Inaudible can be heard, and the Intangible can be felt. Not as the result of any reasoning, but by the same power by which it sees and feels the postulates on which all reasoning rests, the Human Mind may from the very first have felt that it was in contact with a Mind which was the fountain of its own.

No argument can be conducted without some assumptions. But neither ought any argument to be conducted without a clear understanding what these assumptions are. Having now cleared up the assumptions which are usually made, we can proceed with greater confidence in the discussion of the great problem before us. The origin of particular systems of religious belief is, of course, a mere question of fact. A few of these systems belong to our own time; others have arisen late in the historic ages and in the full light of contemporary evidence. Some, again, are first recognized in the dawn of those ages, and their distinctive features can only be dimly traced through evidence which is scanty and obscure. Religion is the origin of all these systems of Belief, but no one of them represents the origin of Religion. None of them throw any other light on the origin of Religion than as all exhibiting the one essential element in which all Religion consists. And it would be well if men, before philosophizing on the origin of Religion, had a more accurate conception of what they mean by it. The definitions of Religion have been even worse than the definitions of Morality. Just as the attempt is made to account for morals apart from the sense of duty or of obligation in conduct, so is the attempt made to account for Religion apart from the sense of Mind or Will in Nature. The great effort seems to have been to try how the essential idea of Religion could be either most completely eliminated or else most effectually concealed. For example, a feeling of absolute dependence has been specified by Schleiermacher as the essence of Religion. Yet it is evident that a sense of absolute dependence may be urgent and oppressive without the slightest tincture of religious feeling. A man carried off in a flood, and clinging to a log of wood, may have, and must have, a painful sense of absolute dependence on the log. But no one would think of describing this sense as a feeling of Religion. A savage may have a feeling of absolute dependence on his bows and arrows, or on the implements of his chase; or disease may bring home to him a sense of his absolute dependence on the organs of his own body, which alone enable him to use his weapons with success. But it does not follow that the savage has any feeling of Religion towards his bow, or his arrow, or his net, or his fishspear, or even to his own legs and arms. Any plausibility, therefore, which may attach to the proposition which indentifies Religion with the mere sense of dependence, is due entirely to the fact that when men speak of the sense of dependence they suggest the idea of a particular kind of dependence—namely, dependence upon a Being or a Personality, and not dependence upon a thing. That is to say, that the plausibility of the definition is entirely due to an element of thought which it is specially framed to keep out of sight. A sense of absolute dependence on purely physical things does not necessarily contain any religious element whatever. But, on the other hand, a sense of dependence on Personal or Living Agencies, whether they are supposed to be supreme or only superior religions to our own, is a feeling which is essentially religious. But the element in that feeling which makes it religious is the element of belief in a Being or in Beings who havePower and Will. When we say of any man, or of any tribe of men, that they have no Religion, we mean that they have no belief in the existence of any such Being or Beings, or at least no such belief as to require any acknowledgment or any worship[1].

The practice of worship of some kind or another is so generally associated with Religion, that we do not usually think of it otherwise than as a necessary accompaniment. It is a natural accompaniment, for the simple reason that in the very act of thinking of Superhuman Beings the mind has an inevitable tendency to think of them as possessing not only an intellectual but a moral nature which has analogies with our own. It conceives of them as having dispositions and feelings as well as mere Intellect and Will. Complete indifference towards other creatures is not natural or usual in ourselves, nor can it be natural to attribute it to other Beings. In proportion therefore as we ascribe to the Superhuman Personalities, in whose existence we believe, the authorship or the rule over, or even a mere partnership in, the activities round us, in the same proportion is it natural to regard those Beings as capable of exercising some influence upon us, whether for evil or for good. This conception of them must lead to worship—that is to say, to the cherishing of some feeling and sentiment in regard to them, and to some methods of giving it expression. There is, therefore, no mystery whatever in the usual and all but universal association of worship of some kind with all conceptions of a religious nature.

It is to be remembered, however, that, as a matter of fact, the belief in the existence of a God, or more Gods than one, has come, though rarely, to be separated from the worship of them. Among speculative philosophers this separation may arise from theories about the Divine nature, which represent it as inaccessible to supplication, or as indifferent to the sentiments of men. Among savages it may arise from the evolution of decay. It may be nothing but "a sleep and a forgetting"—the result of the breaking up of ancient homes, and the consequent impossibility of continuing the practice of rites which had become inseparably associated with local usages. Among philosophers this divorce between the one essential element of Religion and the natural accompaniments of worship, is well exhibited in the Lucretian conception of the Olympian gods, as well as in the condition of mind of many men in our own day, who have not rejected the idea of a God, but who do not feel the need of addressing Him in the language either of prayer or praise. Of this same

[1] Professor Tiele's definition of Religion corresponds with that here given:—"The relation between Man and the Superhuman Powers in which he believes." ("Outlines of the History of the Ancient Religions," p. 2.)

divorce among savages we have an example in certain Australian tribes, who are said to have a theology so definite as to believe in the existence of one God, the omnipotent Creator of heaven and of earth, and yet to be absolutely destitute of any worship.[2] Both of these, however, are aberrant phenomena—conditions of mind which are anomalous, and in all probability essentially transitional. It has been shown in the preceding pages how impossible it is to regard Australian or any other savages of the present time as representing the probable condition of Primeval man. It needs no argument to prove that it is equally impossible to regard speculative philosophers of any school as representing the mind of the earliest progenitors of our race. But neither of savages nor of philosophers who believe in a God but do not pray to Him, would it be proper to say that they have no Religion. They may be on the way to having none, or they may be on the way to having more. But men who believe in the existence of any Personal or Living Agency in Nature superior to our own, are in possession of the one essential element of all Religion. This belief is almost universally associated with practices which are in the nature of worship—with sentiments of awe, or of reverence, or of fear.

It is not inconsistent with this definition to admit that sects or individuals, who have come to reject all definite theological conceptions and to deny the existence of a living God have nevertheless been able to retain feelings and sentiments which may justly claim to be called religious. In the first place, with many men of this kind. their denial of a God is not in reality a complete denial, What they deny is very often only some particular conception of the Godhead, which is involved, or which they think is involved, in the popular theology. They are repelled, perhaps, by the familiarity with which the least elevated of human passions are sometimes attributed to the Divine Being. Or they may be puzzled by the anomalies of Nature, and find it impossible to reconcile them intellectually with any definite conception of a Being who is both all-powerful and all-good. But in faltering under this difficulty, or under other difficulties of the same kind, and in denying the possibility of forming any clear or definite conception of the Godhead, they do not necessarily renounce other conceptions which, though vague and indefinite, are nevertheless sufficient to form the nucleus of a hazy atmosphere of religious feeling and emotion. Such men may or may not recognize the fact that these feelings and emotions have been inherited from ancestors whose beliefs were purely theological, and that it is in the highest degree doubtful how long these feelings can be retained as mere survivals. It is remarkable that such feelings are even now artificially propped up and supported by a system of investing abstract terms with all the elements of personality. When men who profess to have rejected the idea of a God declare, nevertheless, as Strauss has declared, that "the world is to them the workshop of the Rational and the Good," —when they explain that "that on which they feel themselves to be absolutely dependent is by no means a brute power, but that it is Order and Law, Reason and Goodness, to which they surrender themselves with loving confidence," we cannot be mistaken that the whole of this language, and the whole conceptions which underlie it, are language and conceptions appropriate to Agencies and Powers which are possessed of all the characteristics of Mind and Will. Order and Law are, indeed, in some minds associated with nothing except matter and material forces. But neither Reason nor Goodness can be thus dissociated from the idea of Personality. All other definitions which have been given of Religion will be found on analysis to borrow whatever strength they have from involving, either expressly or implicitly, this one conception. Morality, for example, becomes Religion in proportion as all duty and all obligation is regarded as resting on the sanctions of a Divine authority. In like manner, Knowledge may be identified with Religion in proportion as all knowledge is summed up and comprehended in the perfect knowledge of One who is All in All. Nor is there any real escape from this one primary and fundamental element of Religion in the attempt made by Comte to set up Man himself—Humanity—as the object of religious worship. It is the Human Mind and Will abstracted and personified that is the object of this worship. Accordingly, in the system of Comte, it is the language of Christian and even of Catholic adoration that is borrowed as the best and fullest expression of its aspirations and desires. Such an impersonation of the Human Mind and Will, considered as an aggregate of the past and of the future, and separated from the individual who is required to worship it, does contain the one element, or at least some faint outline and shadow of the one element, which has been here represented as essential to Religion—the element, namely, of some Power in Nature other than mere brute matter or mere physical force—which Power is thought of and conceived as invested with the higher attributes of the Human Personality.

Like methods of analysis are sufficient to detect the same element in other definitions of Religion, which are much more common. When, for example, it is said that "the Supernatural" or "the Infinite" are the objects of religious thought, the same fundamental conception is involved, and is more or less consciously intended. The first of these two abstract expressions, "the Supernatural," is avowedly an expression for the existence and the agency of superhuman Personalities. It is objectionable only in so far as it seems to imply that such agency is no part of "Nature." This is in one sense a mere question of definition. We may choose to look upon our own human agency as an agency which is outside of Nature. If we do so, then, of course, it is natural to think of the agency of other Beings as outside of Nature also. But, on the other hand, if we choose to understand by "Nature" the whole system of things in which we live and of which we form a part, then the belief in the agency of other Beings of greater power does not necessarily involve any belief whatever that they are outside of that system. On the contrary, the belief in such an agency may be identified with all our conceptions of what that system, as a whole, is, and especially of its order and of its intelligibility. Whilst, therefore, "the Supernatural," as commonly understood, gives a true indication of the only real objects of religious thought, it complicates that indication by coupling the idea of Living Agencies above our own with a description of them which at the best is irrelevant, and is very apt to be misleading. The question of the existence of Living Beings superior to Man, and having more or less power over him and over his destinies, is quite a separate question from the relation in which those beings may stand to what is commonly but variously understood by "Nature."

The other phrase, now often used to express the objects of religious thought and feeling, "the Infinite," is a phrase open to objection of a very different kind. It is ambiguous, not merely as "the Supernatural" is ambiguous, by reason of its involving a separate and adventitious meaning besides the meaning which is prominent and essential; but it is ambiguous by reason of not necessarily containing at all the one meaning which is essential to Religion. "The Infinite" is a pure and bare abstraction, which may or may not include the one only object of religious consciousness and thought. An Infinite Being, if that be the meaning of "the Infinite," is indeed the highest and most perfect object of Religion. But an infinite space is no object of religious feeling. An infinite number of material units is no object of religious thought. Infinite time is no object of religious thought. On the other hand, infinite power not only

[2] "Hibbert Lectures," by Max Müller, 1878, pp. 16, 17.

may be, but must be, an object of religious contemplation in proportion as it is connected with the idea of Power in a living Will. Infinite goodness must be the object of religious thought and emotion, because in its very nature this conception involves that of a Personal Being. But if all this is what is intended by "the Infinite" then it would be best to say so plainly. The only use of the phrase, as the one selected to indicate the object of Religion, is that it may be understood in a sense that is kept out of sight. And the explanations which have been given of it are generally open to the same charge of studied ambiguity. "The Infinite" has been defined as that which transcends sense and reason,—that which cannot be comprehended or completely and wholly understood, although it may be apprehended or partially conceived.[3] And no doubt, if this definition be applied, as by implication it always is applied, to the power and to the resources, or to any other feature in the character of an Infinite Being, then it becomes a fair definition of the highest conceivable object of religious thought. But, again, if it be not so applied,—if it be understood as only applying to the impossibility under which we find ourselves of grasping anything which is limitless,—of counting an infinite number of units,—of traversing, even in thought, an infinite space,—of living out an infinite time,—then "the Infinite" does not contain the one essential element which constitutes Religion.

Similar objections apply to another abstract phrase, sometimes used as a definition of the object of religious feeling, namely, "the Invisible." Mere material things, which are either too large to be wholly seen, or too small to be seen at all, can never supply the one indispensable element of Religion. In so far, therefore, as invisibility applies to them only, it suggests nothing of a religious nature. But in so far as "the Invisible" means, and is intended to apply to, living Beings who are out of sight, to Personal Agencies which either have no bodily form, or who are thought of and conceived as separate from such form—in so far, of course, "the Invisible," like "the Infinite," does cover and include the conception without which there can be no Religion.

Definitions of meaning are more or less important in all discussions; but there are many questions in which they are by no means essential, because of the facility of which we refer the abstract words we may be using to the concrete things,—to the actual phenomena to which they are applied. When, for example, we speak of the religion of Mahomet, or of the religion of Confucius, or of the religion of Buddha, we do not need to define what we mean by the word "Religion," because in all of these cases the system of doctrine and the conceptions which constitute those religions are known, or are matters of historical evidence. But when we come to discuss the origin, not of any particular system of belief, but of Religion in the abstract, some clear and intelligible definition of the word Religion becomes absolutely essential, because in that discussion we are dealing with a question which is purely speculative. It is idle to enter upon that speculative discussion unless we have some definite understanding what we are speculating about. In the case of Religion we cannot keep our understanding of the word fresh and distinct by thinking of any well-known and admitted facts respecting the beginnings of belief. There are no such facts to go upon as regards the religion of Primeval Man. Those, indeed, who accept the narrative attributed to the inspired authority of the Jewish Lawgiver have no need to speculate. In that narrative the origin of Religion is identified with the origin of Man, and the Creator is represented as having had, in some form or another, direct communication with the creature He had made. But those who do not accept that narrative, or who, without rejecting it altogether, regard it as so full of metaphor that it gives us no satisfying explanation, and who assume that Religion has had an origin subsequent to the origin of the species, have absolutely nothing to rely upon in the nature of history. There is no contemporary evidence, nor is there any tradition which can be trusted. Primeval man has kept no journal of his own first religious emotions, any more than of his own first appearance in the world. We are therefore thrown back upon pure speculation — speculation indeed, which may find in the present, and in a comparatively recent past, some data for arriving at conclusions, more or less probable, on the conditions of a time which is out of sight. But among the very first of these data, if it be not indeed the one datum without which all others are useless, is a clear conception of the element which is common to all religions as they exist now, or as they can be traced back beyond the dawn of history into the dim twilight of tradition. Of this universal element in all religions "the Infinite" is no definition at all. It is itself much more vague and indefinite in meaning than the word which it professes to explain. And this is all the more needless, seeing that the common element in all religions, such as we know them now, is one of the greatest simplicity. It is the element of a belief in superhuman Beings—in Living Agencies, other and higher than our own.

It is astonishing how much the path of investigation is cleared before us the moment we have arrived at this definition of the belief which is fundamental to all religions. That belief is simply a belief in the existence of Beings of whom our own Being is the type, although it need not be the measure or the form. By the very terms of the definition the origin of this belief is and must be in ourselves. That is to say, the disposition to believe in the existence of such Beings arises out of the felt unity of our own nature with the whole system of things in which we live and of which we are a part. It is the simplest and most natural of all conceptions that the agency of which we are most conscious in ourselves is like the Agency which works in the world around us. Even supposing this conception to be groundless, and that, as some now maintain, a more scientific investigation of natural agencies abolishes the conception of design or purpose, or of personal Will being at all concerned therein,—even supposing this, it is not the less true that the transfer of conceptions founded on our own consciousness of agency and of power within us to the agencies and powers around us, is a natural, if it be not indeed a necessary conception. That it is a natural conception is proved by the fact that it has been, and still is so widely prevalent; as well as by the fact that what is called the purely scientific conception of natural agencies is a modern conception, and one which is confessedly of difficult attainment. So difficult indeed is it to expel from the mind the conception of personality in or behind the agencies of Nature, that it may fairly be questioned whether it has ever been effectually done. Verbal devices for keeping the idea out of sight are indeed very common; but even these are not very successful. I have elsewhere pointed out[4] that those naturalists and philosophers who are most opposed to all theological explanations or conceptions of natural forces do, nevertheless, habitually, in spite of themselves, have recourse to language which derives its whole form as well as its whole intelligibility, from those elements of meaning which refer to the familiar operations of our own Mind and Will. The very phrase "Natural Selection" is one which likens the operations of Nature to the operations of a mind exercising the power of choice. The whole meaning of the phrase is to indicate how Nature attains certain ends which are like "selection." And what "selection" is we know, because it is an operation familiar to ourselves. But the personal element of Will and of purpose lies

[3] Max Müller, "Hibbert Lectures," 1878.

[4] "Reign of Law," Chaps. I. and V.

even deeper than this in the scientific theory of Evolution. When we ourselves select, we may very often choose only among things ready made to our hands. But in the theory of Evolution, Nature is not merely represented as choosing among things ready made, but as at first making the things which are to be afterwards fitted for selection. Organs are represented as growing in certain forms and shapes "in order that" they may serve certain uses, and then as being "selected" by that use in order that they may be established and prevail. The same idea runs throughout all the detailed descriptions of growth and of development by which these processes are directed to useful and serviceable results. So long as in the mere description of phenomena men find themselves compelled to have recourse to language of this sort, they have not emancipated themselves from the natural tendency of all human thought to see the elements of our own personality in the energies and in the works of Nature. But whether the attempt at such emancipation be successful or not, the very effort which it requires is a proof of the natural servitude under which we lie. And if it be indeed a natural servitude, the difficulty of getting rid of it is explained. It is hard to kick against the pricks. There is no successful rebellion against the servitudes of Nature. The suggestions which come to us from the external world, and which are of such necessity that we cannot choose but hear them, have their origin in the whole constitution and course of things. To seek for any origin of them apart from the origin of our whole intellectual nature, and apart from the relations between that nature and the facts of the universe around us, is to seek for something which does not exist. We may choose to assume that there are no Intelligences in Nature superior to our own; but the fact remains that it is a part of our mental constitution to imagine otherwise. If, on the other hand, we assume that such Intelligences do exist, then the recognition of that existence, or the impression of it, is involved in no other difficulty than is involved in the origin of any other part of the furniture of our minds. What is the origin of Reason? The perception of logical necessity is the perception of a real relation between things; and this relation between things is represented by a corresponding relation between our conceptions of them. We can give no account of the origin of that perception unless we can give an account of the origin of Man, and of the whole system to which he stands related. What, again, is the origin of Imagination? It is the mental power by which we handle the elementary conceptions derived from our mental constitution in contact and in harmony with external things, and by which we combine these conceptions in an endless variety of forms. We can give no account of the origin of such a power or of such a habit. What is the origin of Wonder? In the lower animals a lower form of it exists in the shape of Curiosity, being little more than an impulse to seek for that which may be food, or to avoid that which may be danger. But in Man it is one of the most powerful and the most fruitful of all his mental characteristics. Of its origin we can give no other account than that there exists in Man an indefinite power of knowing, in contact with an equally indefinite number of things which are to him unknown. Between these two facts the connecting link is the wish to know. And, indeed, if the system of Nature were not a reasonable system, the power of knowing might exist in Man without any wish to use it. But the system of Nature, being what it is—a system which is the very embodiment of wisdom and knowledge—such a departure from unity is impossible. That unity consists in the universal and rational correspondence of all its essential facts. There would be no such correspondence between the powers of the human mind and the ideas which they are fitted to entertain, if these powers were not incited by an appetite of inquiry. Accordingly, the desire of knowledge is as much born with Man as the desire of food. The impression that there are things around him which he does not know or understand, but which he can know and understand by effort and inquiry, is so much part of Man's nature that Man would not be Man without it. Religion is but a part of this impression —or rather it is the sum and consummation of all the intimations from which this impression is derived. Among the things of which he has an impression as existing, and respecting which he desires to know more, are above all other things, Personalities or Agencies, or Beings having powers like, but superior to his own. This is Religion. In this impression is to be found the origin of all Theologies. But of its own origin we can give no account until we know the origin of Man.

I have dwelt upon this point of definition because those who discuss the origin of Religion seem very often to be wholly unconscious of various assumptions which are necessarily involved in the very question they propound. One of these assumptions clearly is that there was a time when Man existed without any feeling or impression that any Being or Beings superior to himself existed in Nature or behind it. The assumption is that the idea of the existence of such Beings is a matter of high and difficult attainment, to be reached only after some long process of evolution and development. Whereas the truth may very well be, and probably is, that there never was a time since Man became possessed of the mental constitution which separates him from the brutes, when he was destitute of some conception of the existence of living Agencies other than his own. Instead of being a difficult conception, it may very well turn out to be, on investigation, the very simplest of all conceptions. The real difficulty may lie not in entertaining it, but in getting rid of it, or in restraining its undue immanence and power. The reason of this difficulty is obvious. Of all the intuitive faculties which are peculiar to Man, that of self-consciousness is the most prominent. In virtue of that faculty or power, without any deliberate reasoning or logical process of any formal kind, Man must have been always familiar with the idea of energies which are themselves invisible, and only to be seen in their effects. His own loves and hates, his own gratitude and revenge, his own schemes and resolves, must have been familiar to him from the first as things in themselves invisible, and yet having power to determine the most opposite and the most decisive changes for good or evil in things in themselves invisible, and yet having power to determine the most opposite and the most decisive changes for good or evil in things which are visible and material. The idea of Personality, therefore, or of the efficiency of Mind and Will, never could have been to him inseparable from the attributes of visibility. It never could have been any difficulty with him to think of living Agencies other than his own, and yet without any form, or with forms concealed from sight. There is no need therefore to hunt farther afield for the origin of this conception than Man's own consciousness of himself. There is no need of going to the winds which are invisible, or to the heavenly bodies which are intangible, or to the sky, which is immeasurable. None of these, in virtue either of mere invisibility, or of mere intangibility, or of mere immeasurableness, could have suggested the idea which is fundamental in Religion. That idea was indeed supplied to Man from Nature; but it was from his own nature in communion with the nature of all things around him. To conceive of the energies that are outside of him as like the energies that he feels within him, is simply to think of the unknown in terms of the familiar and the known. To think thus can never have been to him any matter of difficult attainment. It must have been, in the very nature of things, the earliest, the simplest, and the most necessary of all conceptions.

The conclusion, then, to which we come from this analysis of Religion is that there is no reason to believe, but on the contrary many reasons to disbelieve, that there

ever was a time when man with his existing constitution, lived in contact with the forces and in the face of energies of Nature, and yet with no impression or belief that in those energies, or behind them, there were Living Agencies other than his own. And if man, ever since he became Man, had always some such impression or belief, then he always had a Religion, and the question of its origin cannot be separated from the origin of the species.

It is a part of the Unity of Nature that the clear perception of any one truth leads almost always to the perception of some other, which follows from or is connected with the first. And so it is in this case. The same analysis which establishes a necessary connection between the self-consciousness of Man and the one fundamental element of all religious emotion and belief, establishes an equally natural connection between another part of the same self-consciousness and certain tendencies in the development of Religion which we know to have been widely prevalent. For although in the operations of our own mind and spirit, with their strong and often violent emotions, we are familiar with a powerful agency which is in itself invisible, yet it is equally true that we are familiar with that agency as always working in and through a body. It is natural, therefore, when we think of Living Agencies in Nature other than our own, to think of them as having some form, or at least as having some abode. Seeing, however, and knowing the work of those Agencies to be work exhibiting power and resources so much greater than our own, there is obviously unlimited scope for the imagination in conceiving what that form and where that abode may be. Given, therefore, these two inevitable tendencies of the human mind—the tendency to believe in the existence of Personalities other than our own, and the tendency to think of them as living in some shape and in some place—we have a natural and sufficient explanation, not only of the existence of Religion, but of the thousand forms in which it has found expression in the world. For as Man since he became Man, in respect to the existing powers and apparatus of his mind, has never been without the consciousness of self, nor without some desire of interpreting the things around him in terms of his own thoughts, so neither has he been without the power of imagination. By virtue of it he re-combines into countless new forms not only the images of sense but his own instinctive interpretations of them. Obviously we have in this faculty the prolific source of an infinite variety of conceptions, which may be pure and simple or foul and unnatural, according to the elements supplied out of the moral and intellectual character of the minds which are imagining. Obviously, too, we have in this process an unlimited field for the development of good or evil germs. The work which in the last chapter I have shown to be the inevitable work of Reason when it starts from any datum which is false, must be, in religious conceptions above all others, a work of rapid and continuous evolution. The steps of natural consequence, when they are downward here, must be downwards along the steepest gradients. It must be so because the conceptions which men have formed respecting the Supreme Agencies in Nature are of necessity conceptions which give energy to all the springs of action. They touch the deepest roots of motive. In thought they open the most copious fountains of suggestion. In conduct they affect the supreme influence of Authority, and the next most powerful of all influences, the influence of Example. Whatever may have been false or wrong, therefore, from the first in any religious conception must inevitably tend to become worse and worse with time, and with the temptation under which men have lain to follow up the steps of evil consequence to their most extreme conclusions.

Armed with the certainties which thus arise out of the very nature of the conceptions we are dealing with when we inquire into the origin of Religion, we can now approach that question by consulting the only other sources of authentic information, which are, first, the facts which Religion presents among the existing generations of men, and, secondly, such facts as can be safely gathered from the records of the past.

On one main point which has been questioned respecting existing facts, the progress of inquiry seems to have established beyond any reasonable doubt that no race of men now exists so savage and degraded as to be, or to have been when discovered, wholly destitute of any conceptions of a religious nature. It is now well understood that all the cases in which the existence of such savages has been reported, are cases which break down upon more intimate knowledge and more scientific inquiry.

Such is the conclusion arrived at by a careful modern inquirer, Professor Tiele, who says: "The statement that there are nations or tribes which possess no religion, rests either on inaccurate observations or on a confusion of ideas. No tribe or nation has yet been met with destitute of belief in any higher Beings, and travelers who asserted their existence have been afterwards refuted by facts. It is legitimate, therefore, to call Religion, in its most general sense, an universal phenomenon of humanity."[5]

Although this conclusion on a matter of fact is satisfactory, it must be remembered that, even if it had been true that some savages do exist with no conception whatever of Living Beings higher than themselves, it would be no proof whatever that such was the primeval condition of Man. The arguments adduced in a former chapter, that the most degraded savagery of the present day is or may be the result of evolution working upon highly unfavorable conditions, are arguments which deprive such facts, even if they existed, of all value in support of the assumption that the lowest savagery was the condition of the first progenitors of our race. Degradation being a process which has certainly operated, and is now operating. upon some races, and to some extent, it must always remain a question how far this process may go in paralyzing the activity of our higher powers or in setting them, as it were, to sleep. It is well, however, that we have no such problem to discuss. Whether any savages exist with absolutely no religious conceptions is, after all, a question of subordinate importance; because it is certain that, if they exist at all, they are a very extreme case and a very rare exception. It is notorious that, in the case of most savages and of all barbarians, not only have they some Religion, but their Religion is one of the very worst elements in their savagery or their barbarism.

Looking now to the facts presented by the existing Religions of the world, there is one of these facts which at once arrests attention, and that is the tendency of all Religions, whether savage or civilized, to connect the Personal Agencies who are feared or worshipped with some material object. The nature of that connection may not be always—it may not be even in any case—perfectly clear and definite. The rigorous analysis of our own thoughts upon such subjects is difficult, even to the most enlightened men. To rude and savage men it is impossible. There is no mystery, therefore, in the fact that the connection which exists between various material objects and the Beings who are worshipped in them or through them, is a connection which remains generally vague in the mind of the worshipper himself. Sometimes the material object is an embodiment; sometimes it is a symbol; often it may be only an abode. Nor is it wonderful that there should be a like variety in the particular objects which have come to be so regarded. Sometimes they are such material objects as the heavenly bodies. Sometimes they are natural productions of our own planet, such as particular trees, or particular animals, or particular things in themselves inanimate, such as springs, or streams, or

[5] "History of Religion," p. 6.

mountains. Sometimes they are manufactured articles, stones or blocks of wood cut into some shape which has a meaning either obvious or traditional.

The universality of this tendency to connect some material objects with religious worship, and the immense variety of modes in which this tendency has been manifested, is a fact which receives a full and adequate explanation in our natural disposition to conceive of all Personal Agencies as living in some form and in some place, or as having some other special connection with particular things in Nature. Nor is it difficult to understand how the embodiments, or the symbols, or the abodes, which may be imagined and devised by men, will vary according as their mental condition has been developed in a good or in a wrong direction. And as these imaginings and devices are never, as we see them now among savages, the work of any one generation of men, but are the accumulated inheritance of many generations, all existing systems of worship among them must be regarded as presumably very wide departures from the conceptions which were primeval. And this presumption gains additional force when we observe the distinction which exists between the fundamental conceptions of religious belief and the forms of worship which have come to be the expression and embodiment of these. In the Religion of the highest and best races, in Christianity itself, we know the wide difference which obtains between the theology of the Church and the popular superstitions which have been developed under it. These superstitions may be, and often are, of the grossest kind. They may be indeed, and in many cases are known to be, vestiges of Pagan worship which have survived all religious revolutions and reforms; but in other cases they are the natural and legitimate development of some erroneous belief accepted as part of the Christian creed. Here, as elsewhere, Reason working on false data has been, as under such conditions it must always be, the great agent in degradation and decay.

METEOROLOGICAL ELECTRICITY.

Ciel et Terre gives a description of a cyclone which passed over Japan on the night of the 3d or 4th of October, 1880. At Tokio a rapidity of 45 metres per second has been observed, but this had only a rapidity of 10 metres; its diameter was not very considerable, 240 kilometres. The fall of the barometer, though rapid, was far from being as prompt as that occurring eight days before on the coasts of the Island of Formosa, where a depression of 73 millimetres in 4 hours, or 18 millimetres per hour, was observed. These indicate that the old theory of whirlwinds is perfectly useless to account for meteorological phenomena.

THE APERTURE OF MICROSCOPE-OBJECTIVES.

The last number of the *Journal* of the Royal Microscopical Society is largely occupied with a discussion of this question by Prof. E. Abbe, of Jena, and Mr. Frank Crisp, one of the secretaries of the Society.

The subject appears to have been again brought up by a paper by Mr. G. Shadbolt (President of the Society in 1856), who claimed to have "demonstrated beyond dispute that no objective could have an aperture of any kind in excess of 180° angular in air." The grounds on which Mr. Shadbolt rested his demonstration are disposed of in detail in the papers now published; but with this aspect of the matter we do not propose to deal, confining ourselves to the more general consideration of the subject, apart from any controversial matter.

The proper definition of the aperture of a microscope-objective was, for a long time, as is well known, a very vexed one among microscopists. The astronomer has always a ready definition for the telescope, the aperture of which was simply estimated by the absolute diameter of the object-glass. No such absolute measure is, however, possible in the case of the microscope-objective, as the lenses of which it is composed vary in diameter within considerable limits, and the larger lens is by no means the larger aperture, as is readily seen by the comparison of the large lenses of the low powers with the small lenses of the high powers, which yet much exceed the former in aperture.

In consequence of this difficulty, the angle of the pencil, as it emanates from the object, and prior to its transmission through the objective to the image, came to be very generally considered as the proper measure of the aperture of the objective. This was at a time when dry or air objectives were generally known, immersion objectives not having been brought into ordinary use.

But even with air objectives the angle of the radiant pencil did not afford a true comparison, which could only be made by the *sines* of the angles; but when immersion objectives were originated—that is, objectives in which water or oil replaced the air in front of the objective—the use of the angles became very misleading, for now three angles might all have the same number of degrees and yet denote very different values, according as they are in air, water, or oil.

It therefore became necessary to find a substitute for the angles in the comparison of apertures; for although it was no doubt possible to bear in mind that 82° in air was less aperture than 82° in water, and the latter less than 82° in oil, yet the use of the same figures inevitably tended to produce confusion in the minds of microscopists—so much so that it was stoutly maintained by one party that the apertures in the three cases we have referred to were identical because the angles were the same.

A solution of the difficulty was discovered by Professor Abbe, who pointed out that the true definition of aperture (in its legitimate meaning of "opening") was obtained when we compared the diameter of the pencil emerging from the objective with the focal length of the objective.

It will be desirable to explain somewhat more in detail how this conclusion is arrived at—as given in Prof. Abbe's paper.

Taking in the first case a *single*-lens microscope, the number of rays admitted within one meridional plane of the lens evidently increases as the diameter of the lens (all other circumstances remaining the same), for in the microscope we have at the back of the lens the same circumstances as are in front in the case of the telescope. The larger or smaller number of emergent rays will, therefore, be properly measured by the clear diameter; and as no rays can *emerge* that have not first been *admitted*, this must also give the measure of the admitted rays.

Suppose now that the focal lengths of the lenses compared are not the same,—what then is the proper measure of the rays admitted?

If the two lenses have equal openings but different focal lengths, they transmit the same number of rays to equal areas of an image at a definite distance, because they would admit the same number if an object were substituted for the image—that is, if the lens were used as a telescope-objective. But as the focal lengths are different the amplification of the images is different also, and equal areas of these images correspond to different areas of the object from which the rays are collected. Therefore, the higher-power lens, with the same opening as the lower power, will admit a *greater* number of rays in all from the same object because it admits the *same* number as the latter from a *smaller* portion of the object. Thus if the focal lengths of the two lenses are as 2:1, and the first amplifies N diameters, the second will amplify 2 N with the same distance of the image, so that the rays which are collected *to* a given field of 1 mm. diameter of

the image are admitted *from* a field of $\frac{1}{N}$ mm. in the first case and of $\frac{1}{2N}$ mm. in the second. Inasmuch as the "opening" of the objective is estimated by the diameter (and not by the area) the higher-power lens admits *twice* as many rays as the lower power, because it admits the *same* number from a field of *half* the diameter, and in general the admission of rays with the same opening, but different powers, must be in the inverse ratio of the focal lengths.

In the case of the single lens, therefore, its aperture must be determined by *the ratio between the clear opening and the focal length*, in order to define the same thing as is denoted in the telescope by the *absolute* opening.

Dealing with a *compound objective*, the same considerations obviously apply, substituting, however, for the clear opening of the single lens, the diameter of the pencil at its emergence from the black lens of the objective —that is, its clear effective diameter.

All equally holds good, whether the medium in which the objective is placed is the same in the case of the two objectives or different, as an alteration of the medium makes no difference in the power.

Thus we arrive at the general proposition for all kinds of objectives. 1st. When the power is the same, the admission of rays varies with the diameter of the pencil at its emergence. 2nd. When the powers are different the *same admission* requires *different openings* in the proportion of the focal lengths, or, conversely, with the *same opening the admission is in inverse proportion* to the focal length—that is, the objective which has the wider pencil relatively to its focal length has the larger aperture.

Thus we see that, just as in the telescope, the absolute diameter of the object-glass defines the aperture, so in the microscope, the ratio between the utilized diameter of the back lens and the focal length of the objective defines its aperture.

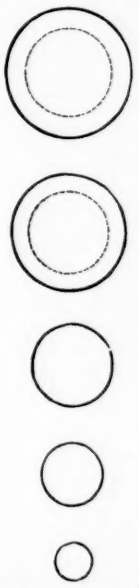
This definition is clearly a definition of aperture in its primary and only legitimate meaning as "opening"—that is, the capacity of the objective for admitting rays from the object and transmitting them to the image; and it at once solves the difficulty which has always been involved in the consideration of the apertures of immersion objectives.

So long as the angles were taken as the proper expression of aperture, it was difficult for those who were not well versed in optical matters to avoid regarding an angle of 180° in air as the maximum aperture that any objective could attain. Hence water-immersion objectives of 96° and oil-immersion objectives of 82° were looked upon as being of much *less* aperture than a dry objective of 180°, whilst, in fact, they are all *equal*—that is, they all transmit the same rays from the object to the image. Therefore, 180° in water and 180° in oil are unequal, and both are much larger apertures than the 180° which is the maximum that the air objective can transmit.

If we compare a series of dry and oil-immersion objectives, and, commencing with very small air-angles, progress up to 180° air-angle, then taking an oil-immersion of 82° and progressing again to 180° oil-angle, the ratio of opening to power progresses continually also, and attains its maximum, not in the case of the air-angle of 180° (when it is exactly equivalent to the oil-angle of 82°), but is greatest at the oil-angle of 180°.

If we assume the objectives to have the same power throughout, we get rid of one of the factors of the ratio, and we have only to compare the diameters of the emergent beams, and can represent their relations by diagrams. Our figure (which is taken from Mr. Crisp's paper) illustrates five cases of different apertures of ¼in. objectives—viz., those of dry objectives of 60°, 97° and 180° air-angle, a water-immersion of 180° water-angle, and an oil-immersion of 180° oil-angle. The inner dotted circles in the two latter cases are of the same size as that corresponding to the 180° air angle.*

RELATIVE DIAMETERS OF THE (UTILIZED) BACK-LENSES OF VARIOUS DRY AND IMMERSION OBJECTIVES OF THE SAME POWER (¼) FROM AN AIR-ANGLE OF 60° TO AN OIL-ANGLE OF 180°.



A dry objective of the full maximum air-angle of 180° is only able (whether the first surface is plane or concave) to utilise a diameter of back lens equal to twice the focal length, while an immersion lens of even only 100° (in glass) requires and utilises a *larger* diameter, *i. e.*, it is able to transmit more rays from the object to the image than *any* dry objective is capable of transmitting. Whenever the angle of an immersion lens exceeds twice the critical angle for the immersion-fluid, *i. e.*, 96° for water or 82° for oil, its aperture is in excess of that of a dry objective of 180°.

Having settled the principle, it was still necessary, however, to find a proper notation for comparing apertures. The astronomer can compare the apertures of his various telescopes by simply expressing them in inches; but this is obviously not available to the microscopist, who has to deal with the *ratio* of two varying quantities.

Prof. Abbe here again conferred a boon upon microscopists by his discovery (in 1873, independently confirmed by Prof. Helmholtz shortly afterwards) that a general relation existed between the pencil admitted into the front of the objective and that emerging from the back of the objective, so that the ratio of the semi-diameter of the emergent pencil to the focal length of the objective could be expressed by the sine of half the angle of aperture (u) multiplied by the refractive index of the medium (n) in front of the objective, or $n \sin. u$ (n being 1.0 for air, 1.33 for water, and 1.5 for oil or balsam).

When, then, the values in any given cases of the expression $n \sin. u$ (which is known as the "numerical aperture") has been ascertained, the objectives are instantly compared as regards their aperture, and, more-

* The explanation of the mistaken supposition that the emergent beam is wider in the case of the immersion objectives because the immersion-fluid abolishes the refractive action of the first plane surface of the objective (which, in air, reduces all pencils to 80° within the glass), belongs rather to the controversial branch of the matter. It is, however, fully dealt with in the papers referred to.

over, as 180° in air is equal to 1.0 (since $n = 1.0$, and the sine of half 180° or 90° = 1.0), we see with equal readiness whether the aperture of the objective is smaller or larger than that corresponding to 180° in air.

Thus, suppose we desire to compare the relative apertures of three objectives, one a dry objective, the second a water-immersion, and the third an oil-immersion. These would be compared on the angular aperture view as, say, 74° air-angle, and 118° balsam-angle; so that a calculation must be worked out to arrive at a due appreciation of the actual relation between them. Applying, however. "numerical" aperture, which gives .60 for the dry objective, .90 for the water-immersion, and 1.30 for the oil-immersion, their relative apertures are immediately appreciated, and it is seen, for instance, that the aperture of the water-immersion is somewhat less than that of a dry objective of 180°, and that the aperture of the oil-immersion exceeds that of the latter by 30 .

When these considerations have been appreciated, the advantage possessed by immersion in comparison with dry objectives is no longer obscured. Instead of this advantage consisting merely in increased working distance or absence of correction-collar, it is seen that a wide-angled immersion objective has a larger aperture than a dry objective of the maximum angle of 180°; so that for any of the purposes for which aperture is desired, an immersion must necessarily be preferred to a dry objective.

The task of making an abstract of these papers was not a light one and we are indebted to the *English Mechanics* for the above résumé.

BOOKS RECEIVED.

DISCOVERY OF THE PREGLACIAL OUTLET OF THE BASIN OF LAKE ERIE INTO THAT OF LAKE ONTARIO; with notes on the Origin of our Lower Great Lakes. By PROF. J. W. SPENCER, B. A. Sc., Ph. D., F. G. S., Kings College, Windsor, N. S. 1881.

As one new branch of knowledge is raised to a science, there still seems to be some other rising to importance. For a long time the explanation of the Physical Features of America has been handed over to the rival Glacier and Iceberg theories, and though much good work has resulted, yet an almost unlimited amount of nonsense has been written, especially by the extreme or ultra-glacial school. During all these years comparatively little attention has been given to the subject of the river geology. more than that many buried channels have been recorded with but few attempts at the reduction of the abstract facts to a branch of Science. There has, however, been a very great difficulty, owing to the Preglacial valleys often being entirely obscured, or, if apparent, an absence of the knowledge of their depths has prevented generalization. In most of the cases recorded, the buried channels have not had courses greatly differing from those of modern times. It has been known for some time that the waters of most of the great lakes had southern outlets when at higher levels, and even to-day the drainage of Chicago passes to the Mississippi. It has been frequently suggested that Lake Ontario emptied by the Mohawk into the Hudson. This, however, was not the case. We are then compelled to place General G. K. Warren as the father of Fluviatile Geology, for he discovered that the Red River of the North (with Lake Winnipeg, the Saskatchewan, and other great rivers of the North West territories of Canada, as tributaries) discharged by the Minnesota river into the Mississippi, and thus produced a river to which no modern water is comparable. On further investigation Gen. Warren's views are found to require some modification, yet this does not detract from the position which may be fairly assigned to him. Dr. Newbury's observations in Ohio have also thrown much additional light on the subject, but a much more important work has been accomplished by Mr. J. F. Carll, of Pennsylvania, when from a careful study of the levels and borings for oil in that State, he discovered that the Upper Alleghany and several other rivers now flowing into the Ohio, formerly emptied into Lake Erie (or its basin).

But the most important contribution on the subject of Fluviatile Geology that has been made is the recent paper of the above title, by Professor Spencer, now of Kings College, Nova Scotia, but formerly residing in the lake region, in the Province of Ontario. The paper of the above title was read before the American Philosophical Society, of Philadelphia, and its publication will be found in the forthcoming proceedings of that Society. It is also being reprinted as an appendix to Report Q 4 of the Pennsylvania Survey, as shown by the maps which accompany the author's edition, of which we have just received a copy. The following is a synopsis of the principal points of the paper:

The Niagara escarpment bends abruptly at the western end of Lake Ontario, and has a height of about 500 feet above the lake. Through this limestone ridge the Dundas valley extends, and enters the extreme western end of the lake. At the narrowest portion of the valley the width is upwards of two miles, and the margins are those of the walls of a perfect *cañon*, 500 feet deep. But by boring near one of its margins, the buried channel is found to reach 227 feet below the surface of Lake Ontario, making a total depth of 743 feet, but with a computed depth in the central part of its course of not less than 1000 feet. The author first discovered that the ancient upper portion of the Grand River left its modern course south of Galt, and although a portion of the old bed is entirely obscured, yet by pursuing the course of the deep wells the ancient route can be traced through the drift to the western end of the Dundas *cañon* and Lake Ontario. In following up this subject Dr. Spencer discovered that the lower portion of the Grand River was formerly an outlet of the Erie basin, which discharged by a course from a point southward of Cayuga (Province of Ontario), and flowed to the westward of this town and entered the present valley, which is two miles wide and eighty feet deep, but underlaid deeply with drift. Westward of Seneca the ancient river left its modern course and passed into the Dundas valley. All these observations are elaborately worked out by levels, deep well borings, and deep ravines, with the one well in this course indicating a depth of 1000 feet of drift in the ancient valley, measuring from the limestone floor of the county.

The outlet of Lake Erie is directly opposite to that of the ancient Alleghany River.

Again, Dr. Spencer has made a study of the soundings of the lakes, and has discovered a long submerged escarpment extending along the southern side of Lake Ontario to near Oswego, at the foot of which the Ancient River from the Dundas Valley ran. The author has shown that an ancient, broad channel, extended from Lake Huron and entered Lake Erie between Port Stanley and Vienna, in the Canadian Province of Ontario. This channel has a marginal depth of 200 feet below Lake Erie, but with a probable depth sufficient to drain Lake Huron.

With regard to Lake Superior, Prof. Spencer shows that it formerly emptied into the northern end of Lake Michigan, and formed a river channel now represented by deep pot-holes. He brings forward some of the evidence showing that Lake Michigan emptied or was completely drained by the tributaries of the Mississippi, and that this lake was probably disconnected from Lake Huron. At the same time, he shows that Lake Superior (when it was at no higher level than at present) did not empty by the Green Bay and valley of the Fox and Wisconsin Rivers.

The author denies the hypothesis of the glacial origin of the Great Lakes, and brings forward strong evidence in support of his views. He correlates with his work and maps the buried channels discovered in Pennsylvania and

Ohio, the whole constituting the broadest study on the "Great River Age" that has been made. He considers the great lakes as largely valleys of subaërial erosion, traversed by the Grand River which he has worked out. The Ancient buried course of the Niagara, the author considers as interglacial, being formed and closed subsequent to the closing of the Dundas Valley. Of course, all this presupposes the action to have been going on when the continent was six hundred feet higher, and from the pot-holes in the New York Harbor, we know it to have had an altitude of at least 900 above the present elevation. To perfect the work there remains the discovery of the outlet of Lake Ontario, which was not by the Mohawk, as in its valley near Little Falls, it passes over hard rock. Yet Prof. Spencer insinuates, in this paper, that he is on the track of this discovery also, and that the study will be pursued during the coming summer. We wish the author every success, and if this ancient outlet be discovered, certainly he will have added much to his already most important discovery, and will fairly be considered as one of the founders of this new scientific development.

It must be further stated that the author does not consider all the ancient buried rivers now running southward, but formerly flowing northward, as having in any way been derived from glacier action, and more recently than the paper, which we are reviewing, a notice by him was read before the American Philosophical Society showing that the Monongahela flowed directly northward by the upper Ohio, Beaver, Mahoning and Grand Rivers of Ohio (the last three reversed in Preglacial times) to Lake Erie, thus adding another important tributary to the Erie Basin and further changing the physical features of the Continent.

This paper, which is the first preliminary notice of his work on the Great River Age, will do much to draw attention to the interesting subject which is destined to have an equal place with Glacial Geology, with the extreme views of which it will be found to conflict more or less.

ON M. C. FAURE'S SECONDARY BATTERY.

The researches of M. Gaston Planté on the polarization of voltameters led to his invention of the secondary cell, composed of two strips of lead immersed in acidulated water. These cells accumulate and, so to speak, store up the electricity passed into them from some outside generator. When the two electrodes are connected with any source of electricity the surfaces of the two strips of lead undergo certain modifications. Thus, the positive pole retains oxygen and becomes covered with a thin coating of peroxide of lead, while the negative pole becomes reduced to a clean metallic state.

Now, if the secondary cell is separated from the primary one, we have a veritable voltaic battery, for the symmetry of the poles is upset, and one is ready to give up oxygen and the other eager to receive it. When the poles are connected, an intense electric current is obtained, but it is of short duration. Such a cell, having half a square metre of surface, can store up enough electricity to keep a platinum wire 1 millim. in diameter and 8 centims. long, red-hot for ten minutes. M. Planté has succeeded in increasing the duration of the current by alternately charging and discharging the cell, so as alternately to form layers of reduced metal and peroxide of lead on the surface of the strip. It was seen that this cell would afford an excellent means for the conveyance of electricity from place to place, the great drawback, however, being that the storing capacity was not sufficient as compared with the weight and size of the cell. This difficulty has now been overcome by M. Faure: the cell as he has improved it is made in the following manner:

The two strips of lead are separately covered with minium or some other insoluble oxide of lead, then covered with an envelope of felt, firmly attached by rivets of lead. These two electrodes are then placed near each other in water acidulated with sulphuric acid, as in the Planté cell. The cell is then attached to a battery so as to allow a current of electricity to pass through it, and the minium is thereby reduced to metallic spongy lead on the negative pole, and oxidised to peroxide of lead on the positive pole; when the cell is discharged the reduced lead becomes oxidised, and the peroxide of lead is reduced until the cell becomes inert.

The improvement consists, as will be seen, in substituting for strips of lead masses of spongy lead; for, in the Planté cell, the action is restricted to the surface, while in Faure's modification the action is almost unlimited. A battery composed of Faure's cells, and weighing 150 lbs., is capable of storing up a quantity of electricity equivalent to one-horse power during one hour, and calculations based on facts on thermal chemistry shows that this weight could be greatly decreased. A battery of 24 cells, each weighing 14 lbs., will keep a strip of platinum ⅝ths of an inch wide, 1-32nd of an inch thick, and 9 feet 10 ins. long, red hot for a long time.

The loss resulting from the charging and discharging of this battery is not great: for example, if a certain quantity of energy is expended in charging the cells, 80 per cent of that energy can be reproduced by the electricity resulting from the discharge of the cells; moreover, the battery can be carried from one place to another without injury. A battery was lately charged in Paris, then taken to Brussels, where it was used the next day without recharging. The cost is also said to be very low. A quantity of electricity can be produced, stored, and delivered at any distance within 3 miles of the works for 1½d. Therefore these batteries may become useful in producing the electric light in private houses. A 1250 horse-power engine, working dynamo machines giving a continuous current, will in one hour produce 1000 horse-power of effective electricity, that is to say 80 per cent of the initial force. The cost of the machines, establishment, and construction will not be more than £40,000, and the quantity of coal burnt will be 2 lbs. per hour per effective horse-power, which will cost (say) ½d. The apparatus necessary to store up the force of 1000 horses for twenty-four hours will cost £48,000, and will weigh 1500 tons. This price and these weights may become much less after a time. The expense for wages and repairs will be less than ¼d. per hour per horse-power, which would be £24 per day, or £8800 a year; thus the total cost of one-horse-power for an hour stored up at the works is ¾d. Allowing that the carriage will cost as much as the production and storing, we have what is stated above, viz., that the total cost within 3 miles of the works is 1½d. per horse-power per hour. This quantity of electricity will produce a light, according to the amount of division, equivalent to from 5 to 30 gas burners, which is much cheaper than gas.—*Chemical News.*

MICROSCOPY.

We offer the following notes culled from the pages of the *Journal of the Royal Microscopic Society*:—

A singular species of Ncarus is described by A. D. Michael, found by him at Land's End, England. It belongs to the genus *Dermaleichus* (Koch) *Analges* (Nitsch) but does not fit into any of the five genera, or sub-genera, into which Robins has divided the group. The leading feature in this curious creature was that the male had the left leg of the second pair conspicuously larger than its fellow on the right side, had a totally different tarsus, and supported by a different and more powerful epimeral and sternal arrangement. This deformity makes this species entirely different to any other *Ncarus*.

Haustein has observed in the central cells of *chara*, chlorophyll-bodies containing starch which could not be regarded as the product of assimilation. C. Dehnecke has now investigated a number of similar instances, in which the starch contained within the chlorophyll-grains appears not to serve the purpose of immediate assimilation, but to be stored up as a reserve material.

A new stereoscopic eye piece has been arranged by Professor E. Abbe. The special feature of this instrument

is the ingenious arrangement whereby, by simply turning the caps with the diaphragms, orthoscopic or pseudoscopic effect can be produced instantly at pleasure. It is more particularly available for tubes of short length for which the Wenham prism is inapplicable.

Powell and Leland have completed a new 1-12 having two front lenses. The maximum numerical aperture is 1.43 (= 140° in crown glass of mean index 1.525), obtained by a front lens several degrees greater than a hemisphere, mounted on a plate of glass .003 inch in thickness, which is itself mounted in the usual metal work by the zone projecting beyond the circumference of the lens. With this front lens the focal distance from the exposed surface of the plate on which the lens is mounted is .007 inches. A second front, nearly a hemisphere, is mounted in the usual way by a burred edge of metal covering the extreme margin of the lens. This front gives a numerical aperture of 1.28 (= 115° in glass) and the focal distance is then 0.16 inch. The third front provides a numerical aperture of 1.0 (=82° in glass, as nearly as possible), and the working distance is then .024 inch – probably the greatest working distance hitherto obtained with a 1-12 of that aperture.

Dr. Reidel, an assistant to Professor Abbe, has found two new fluids suitable for homogeneous objectives. The first is a solution of Gum Damar dissolved in hot oil of cedar-wood. The oil which is obtained in Germany has a refractive index of 1.51 *only*, but by the Damar this can be raised to 1.54. If *carefully distilled* it becomes sufficiently pale and loses its stickiness. The other medium is a solution of *iodate of zinc* in Price's ordinary glycerine ($n = 1.46$). This salt is *very* soluble in glycerine, and a refractive index of 1.56 or more can be obtained, and therefore there is no difficulty in making a solution of 1.52 which is the standard index at 18° cent. Professor Abbe has furnished Mr. Zeiss with a new formula for homogeneous $\frac{1}{6}$, this having a numerical aperture of 1.40 and adjusted for the new fluids.

Mr. T. Charters White, R. M. S., calls for some re-agent suitable for mounting insects; carbolic acid renders the chitinous envelope transparent, but has the same effect on the internal organs also. Dr. Mathews also objected to carbolic acid, as it caused the abdomen of insects thus mounted to collapse. Those who have had some experience in making preparations for insect anatomy will perhaps have suggestions to make.

We lately called attention to infusoria found in cases of epidemic catarrh, called *Asthematos ciliaris*. Dr. Leidy doubted the character of this form and suggested its being a *ciliated epithelium*. Dr. Carter now maintains that it is correct to call it an infusorium, because by culture in mucus outside the body, they increase in number, and they are found in morbid secretions of the conjunctiva where no ciliated epithelia exist—moreover, those remedies only cure the disease which kill the *Asthematos*.

THE STEREORACHYS.

A new specimen of this gigantic and marvellous reptile from the permian schists of Igornay (Saône and Loire) has been presented by M. Gaudry, who gives an exceedingly interesting description of it. Among the results formulated by the learned paleontologist, one of the most striking is the continuity of life of the primary epoch to the secondary one. We are tending more and more to the idea of the slow modifications of terrestrial conditions, and are therefore receiving more and more from the gratuitous supposition of the revolutions of the globe.

To the Editor of "SCIENCE:"

DEAR SIR:—In the last number of your valuable periodical, at the close of a review of Professor Packard's work on the "Brain of the Locust," the writer states: "In view of the loudly trumpeted theory recently revived by Dr. J. J. Mason, after having repeatedly received the *coup de grâce* at the hands of Stieda, Meynert and others that large cells are motor, it is interesting to note that those of the optic ganglion in the locust are among the largest cells in its nervous system."

This is a complete error, so far as I am concerned. No such claim has ever been made by me in any form, by hint, inference or otherwise. In my last paper on the dimensions of nuclei there appears this sentence: "At the same time it may be true that all large cells connect with motor filaments. The sentence which immediately precedes this one clearly proves that I refer here exclusively to the spinal cord of turtles. This is reviving no theory. Yours truly,

JOHN J. MASON.

NEWPORT, *June* 13, 1881.

SUN SPOTS.

The following record of observations, made by Mr. D. P. Todd, Assistant, has been forwarded by Prof. S. Newcomb, U. S. Navy, Superintendent Nautical Almanac Office, Washington, D. C., to Gen. H. B. Hazen.

DATE. APRIL, 1881.	NUMBER OF NEW		DISAPPEARED BY SOLAR ROTATION.		REAPPEARED BY SOLAR ROTATION.		TOTAL NUMBER VISIBLE.		REMARKS.
	Groups.	Spots.	Groups.	Spots.	Groups.	Spots.	Groups.	Spots.	
2, 9 a.m.....	1	5	0	0	1	1	3	10	
3, 10 a.m.....	2	11	1	1	1	2	4	†20	Few faculæ.
5, 8 a.m.....	0	0	0	0	0	0	4	†20	Faculæ.
6, 7 a.m.....	1	3	0	0	1	3	5	†18	Faculæ.
7, 7 a.m.....	1	3	1	5	1	3	4	14	Faculæ.
10, 10 a.m.....	0	3	..	..	0	3	3	8	Faculæ.
11, 8 a.m.....	0	0	0	0	0	0	2	7	Faculæ.
14, 8 a.m.....	2	15	..	..	..	..	3	†20	Faculæ.
15, 8 a.m.....	0	†20	0	0	0	0	3	†40	Faculæ. Many of the spots small.
17, 7 a.m.....	4	15	0	0	3	10	7	†55	
21, 9 a.m.....	0	†60	..	..	..	..	6	†115	Faculæ. Many of the spots small.
23, 7 a.m.....	0	0	1	†20	0	0	4	†85	Faculæ. Many of the spots small. Spots probably disappeared by solar rotation.
24, 9 a.m.....	0	0	1	10	0	0	3	†60	Faculæ. Many of the spots small.
26, 8 a.m.....	1	5	0	10	0	0	4	†55	
28, 7 a.m.....	0	0	2	†45	0	0	3	10	Faculæ.
8 a.m.....	0	0	0	0	0	0	3	10	
30, 9 a.m.....	1	4	2	9	1	4	2	5	Faculæ.

† Approximated.